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ABSTRACT

The study attempted to determine whether the failure of Down Syndrome (DS) individuals to show the modality effect (the tendency to show better short-term memory for brief sequences of auditory rather than visual information) is due to the verbal-expressive demands of oral responding in memory tasks. DS, nonretarded (NR) and MR (non-DS mentally retarded) Ss (N=33) listened to or looked at increasingly-long sequences of single digits and attempted to recall them either orally or manually. Analyses suggested that (1) manual responding failed to enhance auditory recall in either DS or any other Ss; (2) difficulity in recalling auditory stimuli was greatest for DS mentally retarded Ss; and (3) DS auditory difficulty was most apparent in the recall of order information. Findings suggested that the adverse consequences of mental retardation were most apparent in the recall of order information, and that this recall difficulty was greater for DS Ss. (Author/CL)

Auditory Memory Difficulties and Down Syndrome

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Abstract

Nonretarded (NR) individuals typically show better short-term memory for brief sequences of auditory than visual information (the "modality effect"). The present study attempted to determine whether the failure of Down syndrome (DS) individuals to show the modality effect is due to the verbal-expressive demands of oral responding in memory tasks. DS, NR, and MR (non-DS mentally retarded) subjects listened to or looked at increasingly-long sequences of single digits and attempted to recall them either orally or manually. Analyses suggested the following: a) Manual responding failed to enhance auditory recall in either DS or any other subjects; b) Difficulty in recalling auditory stimuli was greatest for DS mentally retarded subjects; and c) DS auditory difficulty was most apparent in the recall of order information.

Auditory Memory Difficulties and Down Syndrome

Considerable evidence indicates that nonretarded (NR) persons show better memory for sequences of auditory than visual information (1-4); this has been referred to as the "modality effect". Conversely, Down syndrome (DS) individuals, who show generally reduced short-term memory ability, either fail to show the modality effect or display the reverse pattern. Their deficient auditory-sequential recall has been confirmed by statistical comparisons among subtests of the Illinois Test of Psycholinguistic Abilities (5-9), factor analyses of, and direct comparisons between, simultaneous versus successive coding tests (10-12), and experimental comparisons between carefully equated auditory and visual short-term memory tasks (7,13). The present study attempted to determine whether one characteristic of these investigations -- the oral response required of the subject -- may have been partly responsible for the auditory-sequential memory deficit displayed by DS individuals. This seems possible given the verbal and articulatory demands of oral serial recall and the severe receptive and expressive language problems of DS and other retarded individuals (14-18).

The experimental paradigm employed herein was similar to that of Marcell and Armstrong (7) who asked subjects to recall orally brief sequences of auditorially- and visually-presented digits. Their auditory and visual tasks

were carefully equated in terms of the instructions used to acquaint subjects with the tasks, the type of stimuli, the sequential manner of presentation, the rate of presentation, and the manner of subject response. The present research manipulated the subject response factor in order to determine whether recall of auditory relative to visual items by DS subjects would be enhanced by the use of a nonverbal, manual response procedure. Other goals included: (a) replicating the finding that NR subjects display the modality effect in traditional serial recall tasks and DS subjects do not, and (b) determining whether DS and non-DS mentally retarded (MR) individuals show similar auditory-visual recall patterns.

Method

Subjects

Table 1 describes the subjects tested in this experiment. Three groups of 11 (9 male, 2 female) DS, MR, and NR subjects were drawn from a public school in the Charleston area and statistically matched on sex and MA; the DS and MR groups were also statistically matched on IQ and CA. School records were reviewed to ensure that retarded subjects were free from known uncorrected seeing or hearing defects. All subjects were screened at the beginning of the experiment for their ability to identify the numbers 1-9 and to reproduce orally and manually, in a series of practice trials, at least two auditory and two visual 2-digit sequences.

Insert Table 1 about here

Apparatus and Stimuli

A Kodak Caramate projector was used to present auditory and visual stimuli. The stimuli were random sequences of the digits 1 to 9 presented at a rate of one item every 1.5 seconds. Practice sets of single digits and two-digit sequences, plus experimental sets of digit sequences of increasing length (two sequences each of two to seven items), were constructed. Visual stimuli were slides of black vinyl adhesive Arabic numerals centered on white backgrounds; their projected sizes on the Caramate screen ranged from 10.2 x 6.7 cm ("1") to 10.2 x 8.9 cm ("4"). Auditory stimuli were tape-recorded numbers spoken by an adult female who intentionally lowered her voice at the end of a sequence.

The following items were used during the manual recall task: 1) A white wooden display board (15.3 cm tall x 66.0 cm wide with a 2.5 cm-deep ledge at the bottom) that remained upright at a 30 angle. Outlined horizontally across the front of the display board were seven unfilled red vinyl adhesive rectangles (each 8.9 cm tall x 7.6 cm wide); 2) Large red vinyl adhesive numbers (the Arabic numerals 1-9) separately centered on nine white wooden blocks of identical dimensions as the rectangles; and 3) Three sections of

blue poster board. One section had red rectangles of the same dimensions as those on the display board. Within these rectangles were numbers of the same type as were on the wooden blocks; the numbers were arranged in left-to-right order from 1-9. The other two sections of poster board were plain.

Procedure

Each subject was tested individually during one session in an unoccupied classroom or testing room in his or her school. Arranged on a table in front of the subject were the Caramate (45 off-center to the subject's right), the display board (45 off-center to the subject's left), and the set of numbered wooden blocks (in front of the subject). The blocks rested on the section of poster board with rectangles and numbers; each numbered block was positioned on the rectangle containing the corresponding number. One section of plain poster board covered the blocks and the other section covered the empty rectangles of the display board.

Before testing began the experimenter, seated at the subject's right, ascertained whether the subject knew his or her numbers by temporarily uncovering the blocks and asking the individual to point in a random order to each of the numbers. The subject was informed that if he or she "did a really good job" during the experiment, then he or she could choose one of several scratch-and-sniff stickers or decals. A practice tape and practice slide set were then administered to familiarize the subject with task demands and ensure

that only those who successfully recalled, orally and manually, two auditory and two visual 2-digit sequences would continue in the experiment. The subject was encouraged through instruction and demonstration to recall stimuli in their correct order.

The experimenter next presented four experimental tasks combining auditory or visual stimulus presentation with oral or manual responding. The subject looked carefully at the sequence of numbers projected on the screen (or listened carefully to the sequence of spoken numbers) and attempted oral or manual recall as soon as the experimenter stopped the machine. Digit sequences of increasing lengths were presented until the subject failed to reproduce the correct digits, in the correct or incorrect order, on two consecutive trials. The subject was informed whenever the number of digits to be recalled would increase. The experimenter recorded the exact sequence recalled as well as the order in which digits were placed on the board during manual responding. The experimenter refrained from giving additional instructions or saying anything between the presentation and recall of stimuli during experimental trials.

The two types of responding were accomplished in the following manners. Prior to stimulus presentation during manual recall the experimenter positioned one section of blank poster board to cover the nine wooden blocks and one to cover those rectangles on the display board that were not to be

used during recall of the upcoming sequence. The experimenter then presented the sequence, immediately uncovered the wooden blocks, and recorded the subject's attempt to place the appropriate blocks in left-to-right order on the display board. During oral recall the numbered blocks remained covered and the display board was not used; the subject simply attempted to repeat aloud the seen or heard numbers after the entire sequence was presented.

The order of presentation for the auditory-oral, auditory-manual, visual-oral, and visual-manual tasks was completely counterbalanced across subjects with the constraint that a subject engage in two tasks differing in modality and response type during each half of the session. Two sets of experimental slides and two sets of experimental tapes were used equally often in oral and manual tasks (e.g., one set of slides was used in visual-oral tasks for half of the subjects and in visual-manual tasks for the remainder of the subjects).

Results

Data analyses are reported in two sections. The first section contains the primary analysis of the study: a consideration of recall of stimuli in their correct order. The second section contains an analysis of stimulus recall regardless of order. All significant main and interaction effects from the analyses of variance were explored by means of the Newman-Keuls' Multiple Range Test. Only pairwise comparisons significant at the .05 level or above were considered.

Analysis of Sequential Recall

"Sequential recall" refers to the retention of stimuli in the correct order. The sequential recall dependent variable was constructed by awarding one point for each digit recalled in its correct position. Thus, a score of 8 in the visual-oral condition might reflect correct recall of two 2-digit sequences and partial recall (2 digits remembered in their correct positions) of each of the 3-digit sequences. The data were submitted to a 3 x 2 x 2 mixed ANOVA with group (DS, MR, NR) as the between-subjects factor and response type (oral, manual) and modality (auditory, visual) as within-subjects variables. All three main effects were significant: group, F (2,30) = 4.33, $p < .02$; response type, F (1,30) = 8.25, $p < .007$; and modality, F (1,30) = 43.78, $p < .00001$. The overall retention score of NR subjects (mean = 14.3) was better than that of DS subjects (6.7); neither differed from MR subjects (10.4). Oral responding resulted in higher memory scores (11.4) than manual responding (9.6), and recall was better for auditory (13.2) than visual (7.8) stimuli.

There was also a significant group x modality interaction effect, F (2,30) = 4.29, $p < .02$. The mean sequential recall scores for each group x modality condition (collapsed over oral and manual response types) are reported in Table 2. Post hoc analyses revealed that the modality effect (better auditory than visual recall) was evidenced by the NR and MR groups, but not by the DS

group. This pattern confirms the NR-DS difference found by previous investigators (e.g., 7, 13) and suggests that auditory short-term memory difficulties are most pronounced in those mentally retarded subjects who possess Down syndrome. It should be noted that although they were not statistically different, the auditory and visual means of the DS group were in the direction of a modality effect. Although it is possible that future testing with larger numbers of subjects may yet reveal a modality effect in DS subjects, it is unlikely that the degree of such a hypothetical effect would resemble that of either NR or MR subjects. The suggestion that auditory difficulties are most pronounced in the DS group is strengthened by the finding that their auditory score was significantly lower than that of MR subjects (whose score was significantly lower than that of NR subjects). Post hoc analyses also revealed that the visual score of the DS group was

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Insert Table 2 about here

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significantly lower than the visual score of the NR group. Thus, relative to NR subjects, both auditory and visual memory scores of DS subjects were depressed; relative to MR subjects, only their auditory memory score was depressed. The notion that DS subjects have especially strong visual recall ability (e.g., 6, 8, 20) is true here only in the sense that the ability is

less impaired than its auditory counterpart. It is possible, though, that this conclusion may extend only to the temporal-sequential types of stimuli employed in this experiment.

Supplementary analyses of the sequential recall data did not reveal why DS subjects failed to show a modality effect. These analyses only indicated that: a) the auditory memory deficit of DS subjects was "general" in that it was not restricted to memory for either primacy or recency items, and b) DS subjects differed from other subjects in neither "self-cueing" (saying numbers aloud to themselves) nor in strategy for selecting and placing blocks during manual recall.

In summary, the results of the sequential recall analyses related to the major hypotheses of this study in the following manner. First, manual placement of stimulus items did not increase the number of items correctly recalled. In fact, oral recall yielded better retention scores across all subjects. Second, both nonretarded and non-DS mentally retarded individuals showed the normal pattern of superior short-term memory for auditory versus visual stimuli, whereas DS subjects did not.

Analyses of Nonsequential Recall

"Nonsequential recall" refers to the retention of stimuli in either the correct or incorrect order. The nonsequential recall dependent variable was constructed by awarding one point for each stimulus recalled regardless of its

position. The data were entered into a 3 x 2 x 2 mixed ANOVA with group as the between factor and response type and modality as within factors. The analysis yielded significant main effects of group, F (2,30) = 4.05, $p < .03$, and modality, F (1,30) = 26.62, $p < .00001$. The patterns of these effects were identical to those reported in the sequential recall analysis: the overall retention score of the NR group (mean = 20.7) was higher than that of the DS group (11.3) (MR mean = 16.5), and recall was better for auditory (19.4) than visual (13.0) stimuli. Interestingly, the response type factor, which was significant in the previous analysis, did not approach significance in the present analysis. This finding suggests that the better recall associated with oral responding in the previous analysis was specific to memory for order information. When nonsequential memory was measured -- i.e., when order information was ignored and only general recall considered -- there was no difference between oral and manual modes of responding.

Although the means of the group x modality interaction were in the same directions as the means of Table 2, the effect was not significant, F (2,30) = 2.39, $p = .11$. Thus, DS (like MR and NR) subjects showed the normal pattern of auditory superiority when memory for item order was not considered. Such a finding is consistent with the notion that DS individuals are most impaired in the sequential processing of information (10-12).

In summary, the results of the nonsequential recall analyses related to the major hypotheses of this study in the following manner. First, manual

placement of stimulus items (relative to oral responding) did not increase the number of items correctly recalled. Second, DS as well as MR and NR groups tended to show a modality effect, suggesting that one source of difficulty in DS short-term recall was memory for item order.

Discussion

The major findings of this experiment will be discussed in relation to the three research questions addressed in the introduction.

1. Does the use of a nonverbal, manual response procedure improve the traditionally poor auditory recall of Down syndrome individuals?

A nonverbal, manual response procedure (placement of blocks) enhanced neither DS auditory recall nor the recall of subjects in any condition or group. Manner of response did not appear to be an important factor in poor DS serial recall. Potential sources of difficulty other than oral responding may eventually prove to be more crucial limiting factors in DS recall. Specific suggestions must await the systematic isolation and investigation of such factors as stimulus concreteness, speed of stimulus identification, subject inattentiveness, and so forth. At present, we believe that our nonverbal response procedure was an effective manipulation; retarded individuals and young nonretarded children experienced little or no difficulty with the task and seemed to enjoy it more than the oral response procedure. Nevertheless, the possibility remains that the procedure itself was somehow not optimal.

Our only suggestion in this regard is that the manual response may have taken too long; subjects might have "lost" information about the order of items while locating and placing the blocks. A future study will need to investigate whether a faster nonverbal response procedure, like silent pointing to representations of numbers, might alter the pattern of DS recall.

The manipulation of response type also revealed that all subjects showed better sequential recall under oral than manual response conditions and no oral-manual difference when protocols were scored for general, nonsequential recall. Thus, subjects more accurately remembered the order of a sequence of numbers when they spoke the sequence rather than reconstructed it manually. Regardless of the modality of input, order information seemed to be maintained in a form that was more closely aligned with articulatory-verbal than manual-verbal response channels. This finding is consistent with that of investigators of normal cognition who concluded that auditory-verbal memory processes are crucial in the short-term retention of order information (23-26). Because Down syndrome and other retarded individuals showed the same oral-manual recall patterns as nonretarded subjects, it can be suggested that they, too, maintain order information in an auditory-verbal format, although at a reduced level of accuracy.

2. Is the modality effect (better short-term recall of auditory than visual stimuli) found in nonretarded but not Down syndrome subjects?

The answer to this question is yes and no. NR subjects showed, and DS subjects failed to show, a clear modality effect when their protocols were scored for ordered recall. The cause of the auditory difficulty in the DS group was unknown; it was related to neither memory for early or late items in a sequence nor to the manner in which subjects manually recalled items. When protocols were rescored for recall of items in any order, both NR and DS subjects showed a modality effect. Although the magnitude of this effect appeared to be much larger for NR subjects, DS subjects nevertheless showed the normal pattern of better auditory than visual recall. These results suggest that part of the auditory difficulty experienced by DS individuals is rooted in poor recall of order information (cf. 10-12). Interestingly, there is recent evidence (27) that severely retarded adults show improved memory span and language imitation abilities following lengthy training on sequential processing tasks.

In considering the above findings one must remember that DS subjects showed lower levels of sequential and nonsequential recall than NR subjects across both auditory and visual tasks. Thus, the short-term memory performance of the DS group was depressed relative to that of the NR group in all realms. Only within-group patterns of recall revealed that DS subjects showed more than just a general depression of short-term memory ability: They also showed relatively greater difficulty than did normal subjects in remembering the order of a sequence of items presented auditorially.

3. Do Down syndrome and non-Down syndrome mentally retarded individuals show similar auditory-visual recall patterns?

The major difference between DS and MR subjects was in their patterns of recall of sequential information: MR subjects showed a modality effect and DS subjects did not. In this respect the memory ability of the MR group was more similar to that of nonretarded than DS subjects. The MR group also showed a higher absolute level of auditory recall of order information than the DS group, indicating that mental retardation alone cannot account for poor DS auditory-sequential recall. The absence of a difference between DS and MR visual memory scores strengthens the suggestion that their greater difficulty is in remembering order information presented auditorially.

It should be noted that the modality effect displayed by the MR group in the recall of sequential information was not as strong as that displayed by the NR group. Although their visual scores did not differ, the MR auditory score was lower than the NR auditory score. Thus, the MR group showed a normal pattern of auditory-visual recall, but nevertheless experienced some degree of difficulty remembering auditory-sequential information. Interestingly, the MR group did not differ from the other groups in nonsequential recall of auditory and visual stimuli. Taken together, these findings suggest that the adverse consequences of mental retardation were most apparent in the recall of order information, and that this recall difficulty was greater for Down syndrome retarded subjects.

TABLE 1

DESCRIPTION OF SUBJECTS

	MA[a]		IQ[b]		CA[c]	
Group	Mean	SD	Mean	SD	Mean	SD
DS	59.7	16.7	26.8	9.7	217.4	35.4
MR	59.6	15.5	25.4	8.9	225.5	18.5
NR	62.6	15.4	86.7	19.4	75.3	14.1

[a]MA = mental age in months. MA was measured by the Age Equivalence index of the Peabody Picture Vocabulary Test-Revised (PPVT-R) (19). The PPVT-R was administered 1-7 days prior to the beginning of the experiment.

[b]IQ = intelligence quotient. IQ was measured by the Standard Score Equivalence index of the PPVT-R. Any child scoring at the bottom of the index was assigned an IQ score of 20.

[c]CA = chronological age in months.

TABLE 2

MEAN SEQUENTIAL RECALL SCORES FOR THE

GROUP X MODALITY INTERACTION

	Auditory		Visual	
Group	Mean	SD	Mean	SD
DS	8.1	5.3	5.2	3.4
MR	12.8	9.6	8.1	7.5
NR	18.6	5.2	10.0	8.4

Note. DS = Down syndrome, MR = non-DS mentally retarded, NR = non-mentally retarded.

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